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THE ROTATION AND MASS OF NGC 1792

V. C. RUBIN, E. M. BURBIDGE, and G. R. BURBIDGE

University of California, San Diego,  
La Jolla, California

0558361

and

0665281

K. H. PRENDERGAST

(Columbia U.)

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ABSTRACT

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The rotation of the Sc galaxy NGC 1792 has been determined. By analysing the observed rotation curve, density distributions and total masses as functions of the assumed c/a ratio of the galaxy have been obtained. It is found that the total mass is very close to  $1.8 \times 10^{10} M_{\odot}$  and the mass-to-light ratio (photographic) is approximately unity. NGC 1792 is very similar in appearance to NGC 157 and NGC 1086, and its rotation curve and total mass are likewise very similar.

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NGC 1792 is an Sc galaxy, similar to NGC 157 and NGC 1084 which have been investigated in earlier papers of this series (Burbidge, Burbidge, and Prendergast 1961, 1963). A plate taken at the prime focus of the 82-inch telescope is reproduced in Figure 1. Although the large number of emission regions present make it an excellent galaxy for spectroscopic investigation, we are not aware of any previous study; this is probably because of its southerly declination ( $\alpha_{1950} = 5^h 3^m 30^s$ ,  $\delta_{1950} = -38^\circ 4'$ ).

Five spectra of NGC 1792 have been obtained with the B spectr graph at the prime focus of the 82-inch telescope. A record of the observations is given in Table 1. The  $H\alpha$  line could be measured from 75" northwest of the center of 60" southeast of the center along the major axis, position angle  $140^\circ$ . This includes the outermost bright regions visible on Figure 1. The spectra were measured and reduced in the manner described in earlier papers in this series (using the Mann two-coordinate measuring machine and CDC 1604 computer at UCSD). The measures in position angle  $160^\circ$ , B 860, are not included in the reductions, because of the strong background lunar spectrum on this plate.

The velocities as a function of distance from the center of the galaxy are listed in Table 2. These velocities have been reduced to the local standard of rest, using the basic solar motion of Vyssotsky and Jansen (1951). From Table 2 it can be seen that velocities obtained from spectra B 839 and B 1216 are approximately constant, indicating that they lie along the minor axis. Since these spectra were taken in position angle  $50^\circ$ , this confirms our choice of  $140^\circ$  as the position angle of the major axis.

From the symmetry of each of the rotation curves in position angles  $140^\circ$  and  $121^\circ$ , and the velocity at the center, a mean recession velocity of +1215 km/sec (uncorrected for galactic rotation) has been adopted. This is

also the mean of the 25 measured velocities along the minor axis. In order to form one mean rotation-curve for the measured velocities in position angles  $140^\circ$  and  $121^\circ$ , the velocities southeast of the nucleus were reflected about the central velocity and the values from position angle  $121^\circ$  were projected to the major axis by means of the usual projection formulae (cf. Burbidge, Burbidge, and Prendergast 1960). The angle  $\xi$  between the line of sight and the normal to the plane of the galaxy was chosen as  $\xi = 64.5^\circ$  from measured contours of the inner and outer regions of the galaxy. With this value, the factors by which the measured distance from the center and the line-of-sight velocity in position angle  $121^\circ$  must be multiplied are, respectively, 1.205 and 1.274, in order to obtain the values they would have along the major axis, in position angle  $140^\circ$ . The resulting velocities are plotted in Figure 2; here each point is the mean of 3 measures. Velocities from [N II]  $\lambda 6583$  have been given half weight in forming these normal points. Although there is some scatter, the rotation-curve is quite well defined and rises approximately linearly to  $y = 60''$ , and decreases sharply beyond.

In the analysis of the rotation curve, all measured points were used, with [N II] values being given half weight. For the galactic model, the surfaces of equal density were assumed to be similar spheroids. The velocity  $V(\tilde{w})$  at distance  $\tilde{w}$  from the center is then related to the density distribution  $\rho(a)$  through the integral equation

$$V^2(\tilde{w}) = 4\pi G (1 - k^2)^{\frac{1}{2}} \int_0^{\tilde{w}} \frac{\rho(a) a^2 da}{(\tilde{w}^2 - k^2 a^2)^{\frac{1}{2}}},$$

where  $k = (a^2 - c^2)^{\frac{1}{2}} / a$ .

The solution of this equation has been described in earlier papers in this series (cf. Burbidge, Burbidge, and Prendergast 1959). For NGC 1792, the solution was carried out using the IBM 7090 machine at the Institute for

Space Studies, NASA, for assumed values of  $c/a = 1/4, 1/5, 1/8, 1/10, 1/12, 1/15$ , and for 3, 4, 5, 6, and 7 parameters. All solutions were well behaved, although the three-parameter rotation curve was not able to approximate the sharp peak near  $y = 60''$ . The rotation curves for the four- and six-parameter solutions are shown in Figure 2. As usual, the solutions were carried out without correcting for the inclination,  $\xi$ , of the galaxy. Densities and masses were later multiplied by  $\text{cosec}^2 \xi$  to take account of this. The relative density curves for an assumed value of  $c/a = 1/10$  are plotted in Figure 3 for the four-, five-, and six-parameter solutions. The total mass is obtained by integrating the density-curve.

To correct the recession velocity for galactic rotation we adopt the value  $\dot{y} = 250$  km/sec for the solar velocity;  $\dot{y}$  directed toward  $l^{\text{II}} = 90^\circ$ ,  $b^{\text{II}} = 0$ . The mean recession velocity is then +1038 km/sec. With a Hubble constant of 75 km/sec/Mpc, the distance of NGC 1792 is  $13.8 \times 10^6$  pc. At this distance,  $1'' = 66.9$  pc; the rotation has been measured over a diameter of  $135'' = 9030$  pc. We show in Table 3 the calculated values for the mass and central density for various values of  $c/a$  and the number of parameters. As has been noted in studies of other galaxies, the total mass is much less sensitive to the choice of parameters than is the central density.

For a galaxy of this type,  $c/a$  must lie between  $1/8$  and  $1/15$ . Hence the total mass is about  $1.8 \times 10^{10} M_\odot$ . The mean density of the galaxy, for  $c/a = 0.1$ , is  $\langle \rho \rangle = 2.4 \times 10^{-23} \text{ gm/cm}^3$ . The mass and mean density for NGC 1792 are very similar to the corresponding values for NGC 1084, which has  $M = 1.6 \times 10^{10} M_\odot$  and  $\langle \rho \rangle = 2 \times 10^{-23} \text{ gm/cm}^3$ . However, the ratio of the central density to the mean density,  $\rho_0 / \langle \rho \rangle$ , ranges from 5 to 21 for NGC 1792, depending on the number of parameters in the solution, and excluding the three-parameter solution. The central density in NGC 1792 is therefore not as low as that found for the other galaxies of this type.

The photographic apparent magnitude given in the Shapley-Ames Catalogue is 10.7. No modern measurements appear to have been made. From this value and correcting for absorption by our Galaxy, we find that  $M_{pg} = -20.2$  and the mass-to-light ratio (photographic) is approximately unity.

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Table 1  
OBSERVATION OF NGC 1792

Spectrum No.	Date	Position Angle	Exposure (minutes)
B 816	Nov. 11, 1961	140°	120
B 827	Nov. 16, 1961	121°	107
B 839	Nov. 20, 1961	50°	84
B 860	Nov. 24, 1961	160°	105
B1216	Jan. 23, 1964	50°	104

Table 2

## VELOCITIES IN NGC 1792 (REDUCED TO LOCAL STANDARD OF REST)

## AS A FUNCTION OF DISTANCE FROM THE CENTER

Distance From Center (Sec. of Arc)	Velocity (km/sec)	Distance From Center (Sec. of Arc)	Velocity (km/sec)	Distance From Center (Sec. of Arc)	Velocity (km/sec)
B 816	P.A. 140°	B 816 (Cont.)	P.A. 140°	B 839	P.A. 50°
H $\alpha$ :		[N II]:		H $\alpha$ :	
N.W. -75.0	+1356	N.W. +48.5	+1008	S.W. -32.7	+1306
-71.4	1336	+52.1	1004	-29.1	1246
-67.8	1346	+55.7	1001	-25.5	1192
-64.1	1341	S.E. +59.4	1012	-21.9	1169
-56.9	1360			-18.2	1199
-53.3	1324	B 827	P.A. 121°	-14.6	1213
-49.7	1318	H $\alpha$ :		-11.0	1159
-46.0	1357	N.W. -51.7	1345	- 7.4	1165
-42.4	1312	-48.1	1378	- 3.8	1164
-38.8	1336	-44.4	1379	- 0.1	1155
-35.2	1306	-40.8	1328	+ 3.5	1183
-31.6	1314	-37.2	1337	+ 7.1	1166
-27.9	1307	-33.6	1300	N.E. +10.7	1149
-24.3	1261	-30.0	1286	B 1216	P.A. 50°
-20.7	1284	-26.3	1264	H $\alpha$ :	
-17.1	1276	-22.7	1249	S.W. -17.5	1240
-13.5	1267	-19.1	1272	-14.6	1239
- 9.8	1251	-15.5	1303	-11.7	1269
- 6.2	1243	-11.9	1280	- 5.9	1267
- 2.6	1234	- 4.6	1295	- 3.0	1236
+ 1.0	1225	- 1.0	1248	- 0.1	1257
+ 4.6	1224	+ 2.6	1202	+ 2.8	1271
+ 8.3	1245	+ 6.2	1163	+ 5.6	1262
+28.7	1125	+27.9	1115	+11.4	1244
+32.3	1107	+31.6	1113	+17.2	1240
+35.9	1044	+35.2	1126	+23.0	1228
+46.8	1117	+38.8	1078	N.E. +28.8	1178
+50.4	1091	+42.4	1067		
+54.0	1049	S.E. +46.0	1095		
+57.6	1061				
S.E. +61.2	1034				

Table 3

## MASS AND CENTRAL DENSITY FROM VARIOUS SOLUTIONS

c/a	No. of Parameters	$M/M_{\odot 10}$ $\times 10^{-10}$	Central Density $\rho_0 \times 10^{23} \text{ (gm/cm}^3\text{)}$
1/4	3	1.82	1.8
1/5	3	1.79	2.2
1/8	3	1.73	3.2
1/10	3	1.71	3.9
1/12	3	1.68	4.5
1/15	3	1.67	5.6
1/4	4	1.95	9.56
1/5	4	1.94	11.4
1/8	4	1.86	16.8
1/10	4	1.83	20.4
1/12	4	1.82	24.0
1/15	4	1.79	29.4
1/4	5	1.85	18.4
1/5	5	1.85	21.8
1/8	5	1.79	32.2
1/10	5	1.77	39.1
1/12	5	1.74	46.0
1/15	5	1.73	56.5
1/4	6	1.76	6.26
1/5	6	1.77	7.43
1/8	6	1.76	11.0
1/10	6	1.73	13.3
1/12	6	1.71	15.7
1/15	6	1.70	19.2
1/4	7	1.74	23.6
1/5	7	1.79	28.1
1/8	7	1.76	41.5
1/10	7	1.76	50.4
1/12	7	1.76	59.2
1/15	7	1.74	72.7

#### FIGURE CAPTIONS

Fig. 1 - NGC 1792, photographed at prime focus of 82-inch telescope on baked Eastman Kodak Ila-0 plate, with no filter. North is at top; west at left. Scale: 1 mm = 2".9.

Fig. 2 - Rotation curve of NGC 1792 (as observed, uncorrected for inclination of galaxy). Points are means of three measures. Velocities measured in P.A. 121° are included, after projection on to major axis in P.A. 140°.

Fig. 3 - Density relative to central value as function of distance from center in NGC 1792, from four-, five-, and six-parameter solutions.

Fig. 2 Rotation and Mass of NGC 1792  
(Rubin, Burbridge, Burbidge and Prendergast)

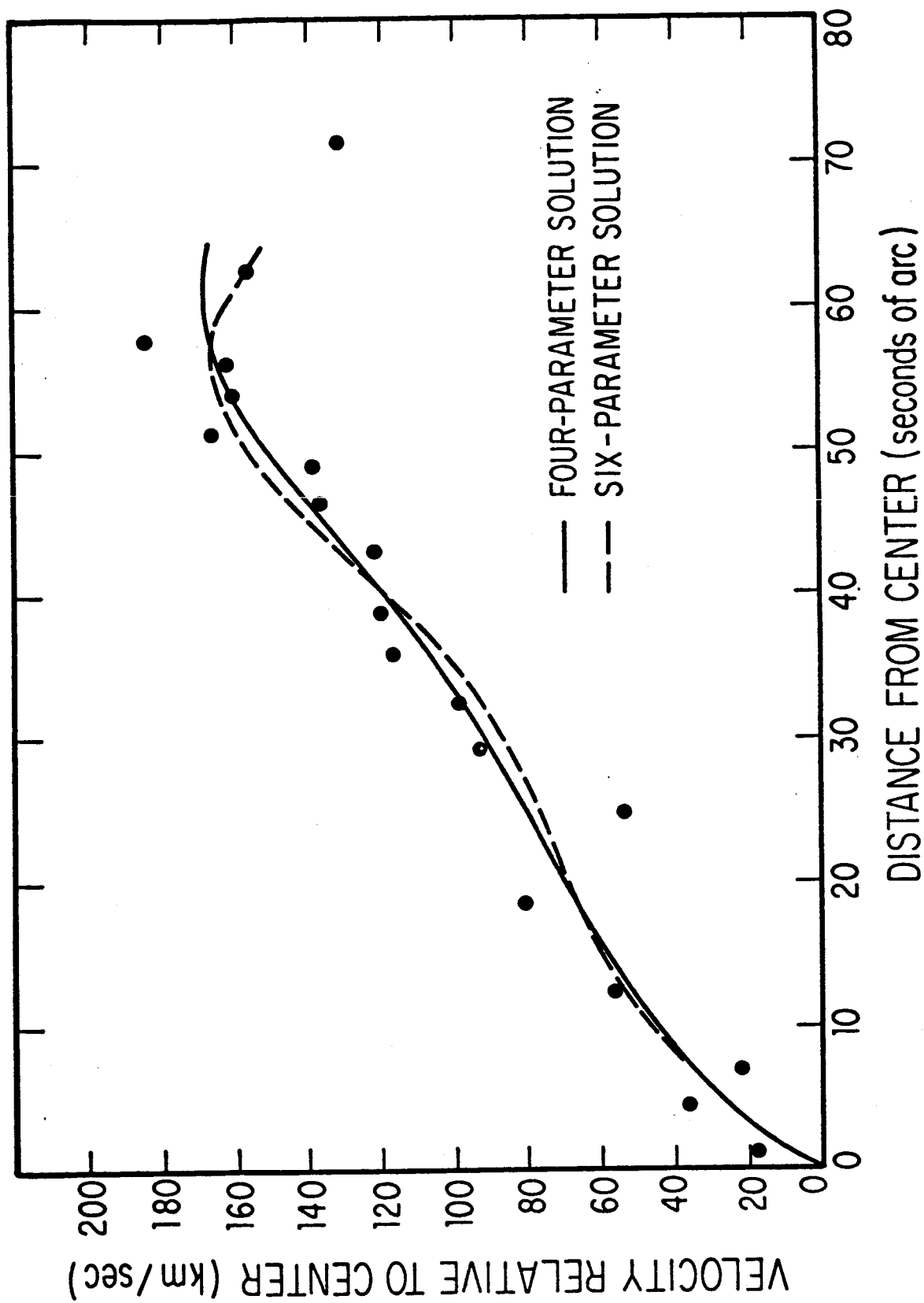


Fig. 3 Rotation and Mass of NGC 1792  
(Rubin, Burbridge, Burbridge and Prendergast)

